*Here is a first draft version of a description of the TOPEX Side B Sigma0 calibration table and its corrections. After this draft was written, it was decided that cycles 277 forward would be reprocessed. That reprocessing will make unnecessary this draft paper's tweaks to sigma0 in cycles 277 forward, but this draft still supplies our best estimate of sigma0 adjustments for cycles earlier than 277. We intend revising and replacing this draft paper after cycles 277-287 have been reprocessed and re-released, and the revised version will correctly describe the reprocessed cycles from 277 forward. --GSH*

# TOPEX Side B Sigma0 Calibration Table Adjustments

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## Introduction

As in all recent spaceborne radar altimeters, TOPEX has an internal calibration mode with two submodes called Calibration Mode 1 and Calibration Mode 2. These will often be referred to simply as Cal 1 or Cal 2 for convenience. In Cal 1 the altimeter tracks a small portion of its own transmitted pulse and makes both a range and a power estimate. In Cal 2 the altimeter looks at the receiver's noise level without any transmitted pulse present. There are two TOPEX calibration modes executed each day and we keep a database of these calibration measurements; specifically we record the changes in the Cal 1 and Cal 2 measurements from an arbitrary reference values selected early in the altimeter's operation. Prior to launch we had expected that a drift in the TOPEX power estimation, hence in its estimation of the sea surface's radar backscattering cross-section sigma0, would be correctable by the observed drift in Cal 1 AGC. The ground processing system at the Jet Propulsion Laboratory (JPL) included a sigma0 Calibration Table (the Alt_Calpars file in JPL's designation, but often here referred to as the Cal Table) which allowed the sigma0 to be corrected by different factors for different data cycles. A per-cycle correction was expected to be adequate because the altimeter's estimates vary relatively slowly with time.

## Brief review of Side A corrections

In TOPEX Side A there were indications that the time trend of the Cal 1 AGC differed from the time trend of the over-ocean cycle-averaged sigma0 in both the Ku- and the C-band systems. We were forced to use the time trend of the over-ocean sigma0 cycle-averages to produce the sigma0 Cal Table entries. We tried to make these corrections only for relatively long times, avoiding responding to cycle-to-cycle noise. Correcting a noisy process by making trend estimates projections is a frustrating activity at best, and the Side A Cal Table has several places where we failed to detect trend changes or to correct our trend projections soon enough. After TOPEX was

switched to its Side B in early February 1999 we described the entire Side A Cal Table history in "TOPEX sigma0 calibration table history for all Side A data", G.S. Hayne and D.W. Hancock III, 27 July 1999, available at http://topex.wff.nasa.gov/docs/Sigma0Cal_A_All.pdf . In that paper we produced our best guess at what values the Cal Table should have included. This best guess was obtained from a quadratic trend fit to the entire Side A set of over-ocean cycle-averages of sigma0.

**Initial corrections in Side B**

When Side B was turned on, we continued to do as we had done for Side A. The initial Side B Cal Table entries were chosen in a committee process, involving Phil Callahan and others, so that there was no obvious discontinuity in over-ocean sigma0 from Side A to Side B. These initial Cal Table values were held constant for a while until trends seemed to appear.

The Side B C-band Cal Table values were changed beginning with cycle 248 to correct for an apparent downward trend in the C-band over-ocean sigma0. No corrections were made to the Side B Ku-band Cal Table until cycle 259 when it became clear that there was an upward trend in the Ku-band over-ocean sigma0. Both the Ku- and the C-band Cal Table values were produced by assuming a linear trend in the over-ocean sigma0. The Ku-band system was particularly surprising in showing an increase in over-ocean sigma0 estimates before correction. Eventually it became clear that the linear trends in the Cal Table were over-correcting the data, and the Cal Table values were held constant until the data trends caught up with the correction; this Cal Table freeze was made at cycle 274 for Ku-band and at cycle 278 for C-band.

Table 1 summarizes the Side B Cal Table values. Column 1 of Table 1 is the data cycle number, and columns 2 and 3 give the Ku- and C-band Cal Table values which were used in producing the TOPEX GDR data product.

**Current status of Side B power measurements**

Figures 1a summarizes the Side B Ku-band altimeter's Cal 1, Cal 2, transmit power monitor, and over-ocean sigma0 cycle averages for cycles 236 - 284, and Figure 1b presents the corresponding information for the C-band altimeter. A small seasonal correction, derived from the entire set of Side A sigma0 data, has been applied to the over-ocean sigma0 averages. Notice that the Cal Table corrections have been removed from the over-ocean sigma0 in these figures, because our purpose is to see the trends in absence of Cal Table corrections. In Figures 1a and 1b the Cal 1 delta AGC trend is in quite good agreement with the over-ocean sigma0 trend, suggesting that the Cal 1 AGC change would provide an adequate basis for the Side B Cal Table (unlike the Side A altimeter where the Cal 1 trend differed from the over-ocean sigma0 trend).

Another effect visible in Figures 1a is an apparent step-change in both the Ku-band Cal 1 and the Ku-band over-ocean sigma0. This step occurred at cycle 256 which was a SSALT cycle during which a satellite safe hold occurred with the result that the TOPEX altimeter was powered off during most of cycle 256. During a normal SSALT cycle the TOPEX altimeter is still powered but is in its standby mode. We don't know why but the TOPEX altimeter behaves differently

before and after this cycle 256 event. There is a visible step-change seen in Figure 1a, and there is also a change in the Ku-band altimeter's track acquisition behavior in land-to-water transitions. Before cycle 256 there were occasional cases of the Ku-band altimeter's requiring several tens of seconds for acquisition, but after the cycle 256 safe hold the Ku-band land-to-water track transitions no longer show the occasional anomalous long acquisition times. For whatever unknown reason, the Side B altimeter behaves differently after the cycle 256 safe hold. The C-band altimeter Figure 1b shows less magnitude of effect than the Ku-band Figure 1a, but there does appear to be a small C-band step change at cycle 256 in Figure 1b.

**New Values for Side B Sigma0 Cal Table**

Based on Figures 1a and 1b, we decided to use the Cal 1 data as the entire basis for the Side B sigma0 Cal Table. We further decided to fit straight line segments to the Side B Cal 1 data, with different slope and intercept values before and after cycle 256 to allow for a possible step change in altimeter characteristics. Figure 2a shows the Ku-band Side B Cal 1 AGC and the fitted line segments, and Figure 2b shows the same thing for C-band. The error bars shown in Figures 2a and 2b are the estimated individual standard deviations of the 20 calibration mode results from which the cycle averages are formed, but in the least squares fit for the straight line segments the cycle means were equally weighted. The (negative of) the Figure 2 data provide a relative correction, and it was arbitrarily decided to set the Cal 1-based corrections to zero at cycle 240; that is, we assumed that +0.45 dB was the correct Ku-band Cal Table value and that +0.55 dB was the correct C-band Cal Table value at cycle 240. This allows us to calculate the values given in columns 4 and 5 of Table 1. These are our best current guess at the values which should have been in the Cal Table, and if one were to recalculate GDRs one should use the column 4 and 5 numbers as replacements for the values in columns 2 and 3 which were used in the original GDR production.

In practical terms we can find the "delta correction" values to be added to the current GDR sigma0 values to produce those sigma0 values which would have been obtained if the ground processing had used Table 1's column 4 and 5 values instead of column 2 and 3. These delta correction values are given in columns 6 and 7 of Table 1, and are plotted in Figure 3. Figure 3 shows that the Ku-band sigma0 values for cycles 257 and 258 are the worst, the most in need of additional adjustment. This is not surprising, given that no change in the Ku Cal Table was made from start of Side B until cycle 259.

**Conclusion**

We have reviewed the Cal Table values used in producing the currently distributed Side B TOPEX GDR sigma0 estimates, we have described our current best guess at what the Cal Table values should have been, and we have given a set of additive data correction values to be applied to the GDR sigma0. These data corrections vary slowly enough that a single value is adequate over a cycle, but the values change with each cycle. Columns 6 and 7 give these data correction values which are plotted in Figure 3. After another half year or so we will have to revisit this work and to write an update to this memo, but we have given here our current best estimate at how to correct the Side B sigma0 data from cycles 236 through 284.

**Figure 1a. Ku-Band Cycle-Average Cal 1 and Cal 2 Delta AGC and Sigma0 (Cal Table Corrections Removed).**

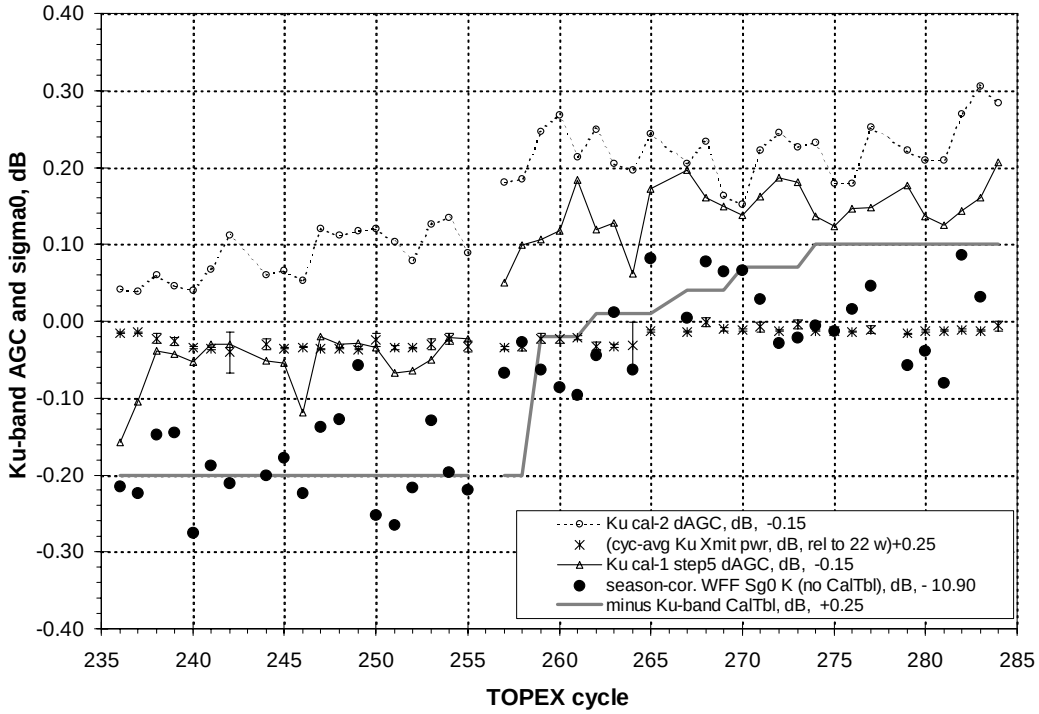



**Figure 1b. C-Band Cycle-Average Cal 1 and Cal 2 Delta AGC and Sigma0 (Cal Table Corrections Removed).**

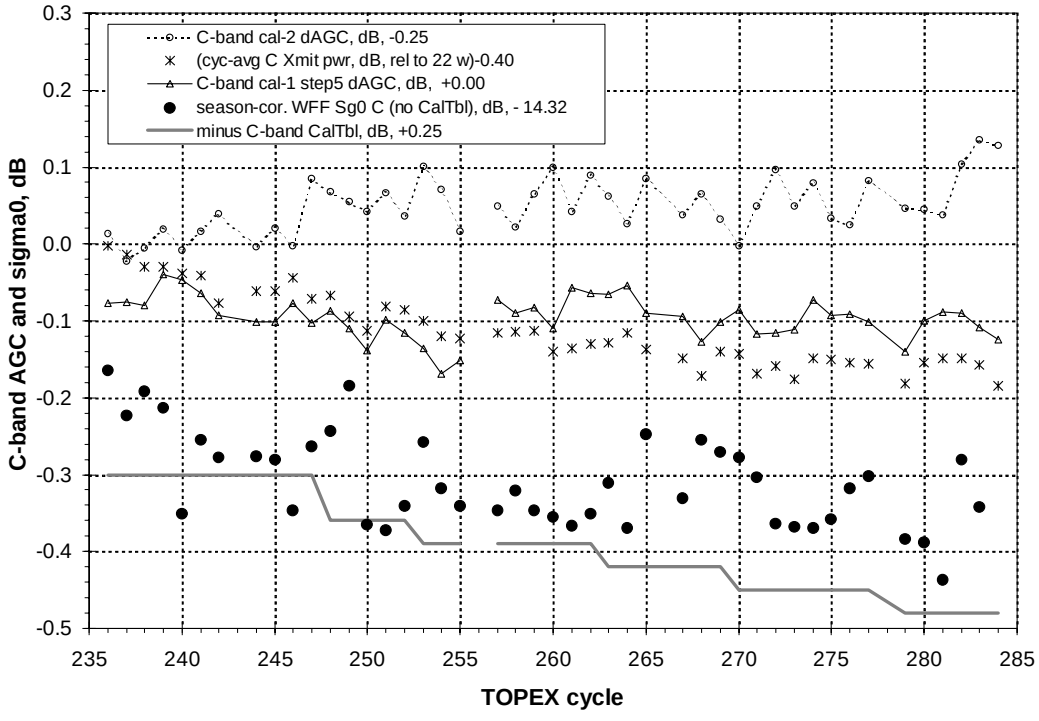


**Figure 2a. TOPEX Side B Ku-Band Cal 1 Delta AGC vs. Cycle**
**fitted by 2 discontinuous line segments, changing at cycle 256**

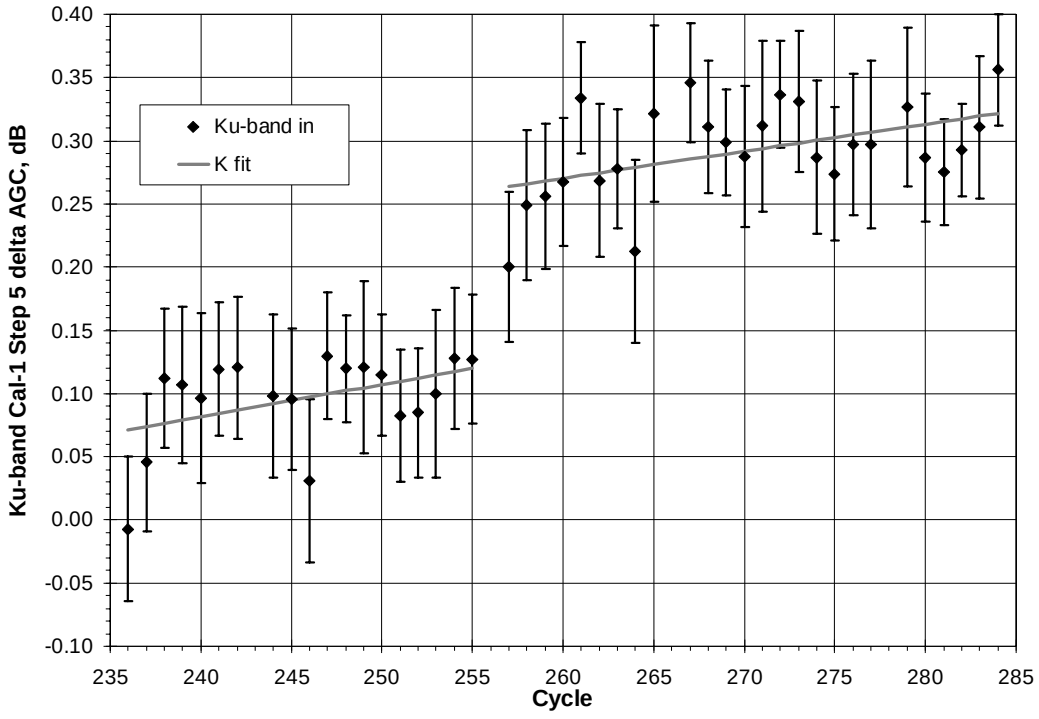



**Figure 2a. TOPEX Side B C-Band Cal 1 Delta AGC vs. Cycle**
**fitted by 2 discontinuous line segments, changing at cycle 256**

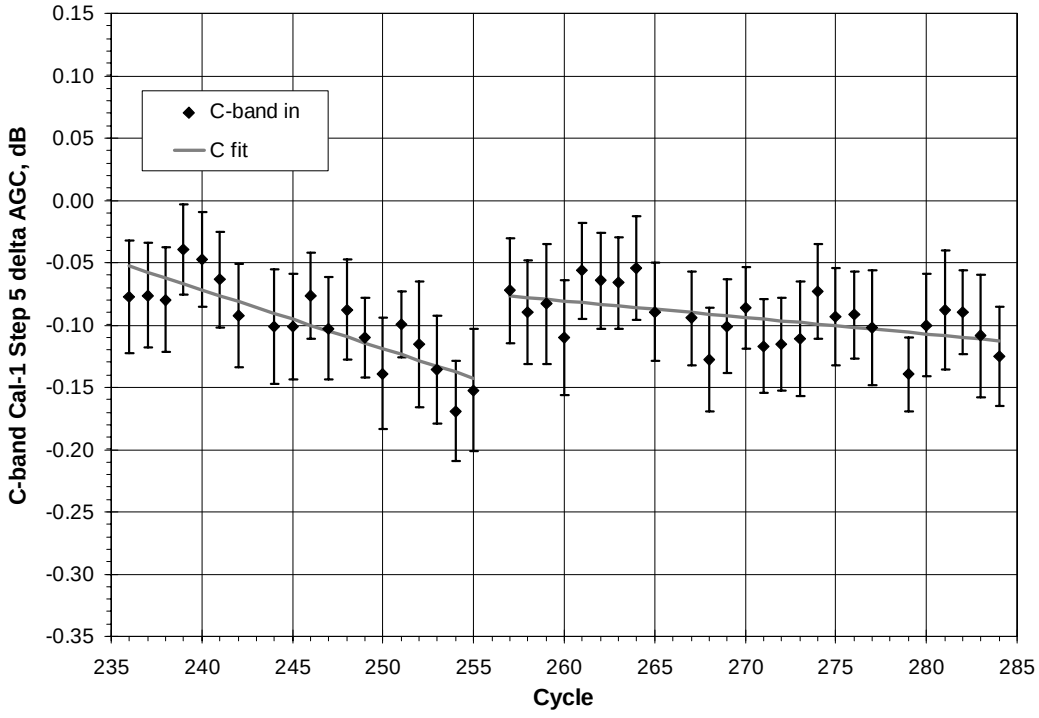
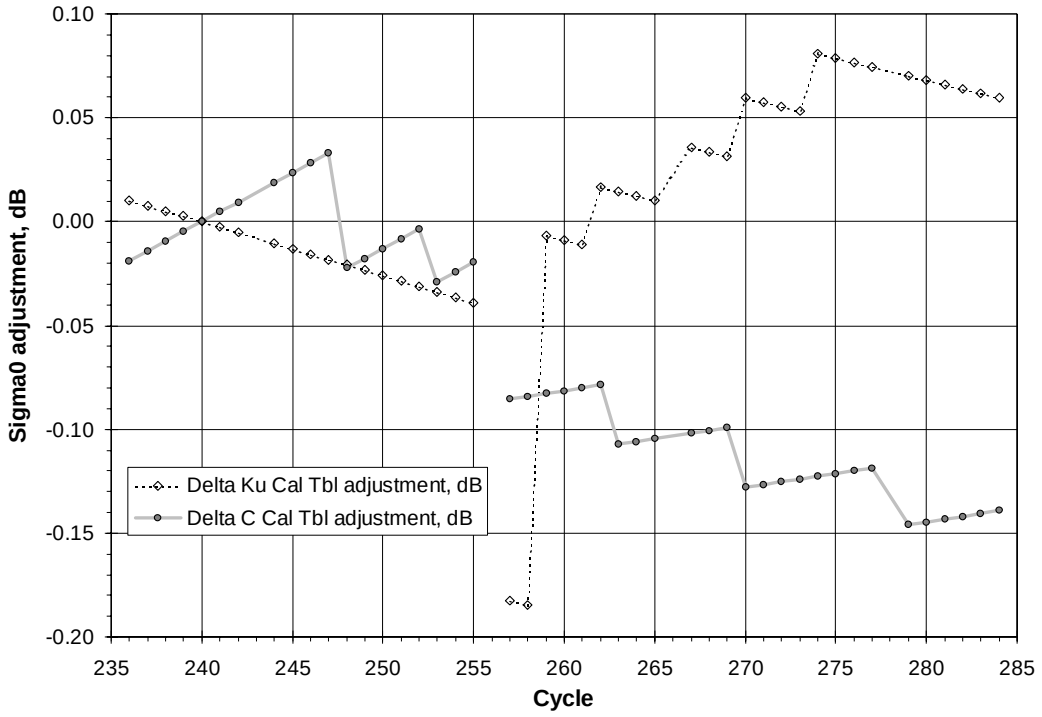


**Figure 3. "Delta" Cal Table, Amount to be Added to Sigma0**
**based on 2-segment fit to Cal 1 AGC for cycles 236 - 284, assuming that Cal 1 provides entire needed Cal Table correction.**



# Table 1. TOPEX Sigma0 Cal Table Values, in dB, for Cycles 236-284

| *col. 1* | *col. 2* | *col. 3* | *col. 4* | *col. 5* | *col. 6* | *col. 7* |
|---|---|---|---|---|---|---|
| **TOPEX Data Cycle** | **Ku-band Cal Table Value in GDR Processing** | **C-band Cal Table Value in GDR Processing** | **Replacement Ku-band Cal Table Value** | **Replacement C-band Cal Table Value** | **Ku-band Adjustment to GDR sigma0** | **C-band Adjustment to GDR sigma0** |
| 236 | +0.45 | +0.55 | +0.460 | +0.531 | +0.010 | -0.019 |
| 237 | +0.45 | +0.55 | +0.458 | +0.536 | +0.008 | -0.014 |
| 238 | +0.45 | +0.55 | +0.455 | +0.541 | +0.005 | -0.009 |
| 239 | +0.45 | +0.55 | +0.453 | +0.545 | +0.003 | -0.005 |
| 240 | +0.45 | +0.55 | +0.450 | +0.550 | +0.000 | +0.000 |
| 241 | +0.45 | +0.55 | +0.447 | +0.555 | -0.003 | +0.005 |
| 242 | +0.45 | +0.55 | +0.445 | +0.559 | -0.005 | +0.009 |
| 244 | +0.45 | +0.55 | +0.440 | +0.569 | -0.010 | +0.019 |
| 245 | +0.45 | +0.55 | +0.437 | +0.574 | -0.013 | +0.024 |
| 246 | +0.45 | +0.55 | +0.434 | +0.578 | -0.016 | +0.028 |
| 247 | +0.45 | +0.55 | +0.432 | +0.583 | -0.018 | +0.033 |
| 248 | +0.45 | +0.61 | +0.429 | +0.588 | -0.021 | -0.022 |
| 249 | +0.45 | +0.61 | +0.427 | +0.592 | -0.023 | -0.018 |
| 250 | +0.45 | +0.61 | +0.424 | +0.597 | -0.026 | -0.013 |
| 251 | +0.45 | +0.61 | +0.421 | +0.602 | -0.029 | -0.008 |
| 252 | +0.45 | +0.61 | +0.419 | +0.606 | -0.031 | -0.004 |
| 253 | +0.45 | +0.64 | +0.416 | +0.611 | -0.034 | -0.029 |
| 254 | +0.45 | +0.64 | +0.414 | +0.616 | -0.036 | -0.024 |
| 255 | +0.45 | +0.64 | +0.411 | +0.621 | -0.039 | -0.019 |
| 257 | +0.45 | +0.64 | +0.267 | +0.555 | -0.183 | -0.085 |
| 258 | +0.45 | +0.64 | +0.265 | +0.556 | -0.185 | -0.084 |
| 259 | +0.27 | +0.64 | +0.263 | +0.557 | -0.007 | -0.083 |
| 260 | +0.27 | +0.64 | +0.261 | +0.559 | -0.009 | -0.081 |
| 261 | +0.27 | +0.64 | +0.259 | +0.560 | -0.011 | -0.080 |
| 262 | +0.24 | +0.64 | +0.257 | +0.561 | +0.017 | -0.079 |
| 263 | +0.24 | +0.67 | +0.255 | +0.563 | +0.015 | -0.107 |
| 264 | +0.24 | +0.67 | +0.252 | +0.564 | +0.012 | -0.106 |
| 265 | +0.24 | +0.67 | +0.250 | +0.565 | +0.010 | -0.105 |
| 267 | +0.21 | +0.67 | +0.246 | +0.568 | +0.036 | -0.102 |
| 268 | +0.21 | +0.67 | +0.244 | +0.569 | +0.034 | -0.101 |
| 269 | +0.21 | +0.67 | +0.242 | +0.571 | +0.032 | -0.099 |
| 270 | +0.18 | +0.70 | +0.240 | +0.572 | +0.060 | -0.128 |
| 271 | +0.18 | +0.70 | +0.237 | +0.573 | +0.057 | -0.127 |
| 272 | +0.18 | +0.70 | +0.235 | +0.575 | +0.055 | -0.125 |
| 273 | +0.18 | +0.70 | +0.233 | +0.576 | +0.053 | -0.124 |
| 274 | +0.15 | +0.70 | +0.231 | +0.577 | +0.081 | -0.123 |
| 275 | +0.15 | +0.70 | +0.229 | +0.579 | +0.079 | -0.121 |
| 276 | +0.15 | +0.70 | +0.227 | +0.580 | +0.077 | -0.120 |
| 277 | +0.15 | +0.70 | +0.225 | +0.581 | +0.075 | -0.119 |
| 279 | +0.15 | +0.73 | +0.220 | +0.584 | +0.070 | -0.146 |
| 280 | +0.15 | +0.73 | +0.218 | +0.585 | +0.068 | -0.145 |
| 281 | +0.15 | +0.73 | +0.216 | +0.587 | +0.066 | -0.143 |
| 282 | +0.15 | +0.73 | +0.214 | +0.588 | +0.064 | -0.142 |
| 283 | +0.15 | +0.73 | +0.212 | +0.589 | +0.062 | -0.141 |
| 284 | +0.15 | +0.73 | +0.210 | +0.591 | +0.060 | -0.139 |